

Illustration of Proliferation Resistance Assessment Methodology Through the French Fuel Cycle

C. Xerri – AREVA

D. Grenèche–AREVA, J.Cl. Gauthier–CEA, S. Grit-DGEMP

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- ▶ ***Proliferation Resistance***
 - ◆ ***Definition and key concepts***
- ▶ ***Intrinsic features, Extrinsic measures***
 - ◆ ***and the concept of barriers defined in TOPS***
- ▶ ***Illustration of barriers***
 - ◆ ***Extrinsic***
 - ◆ ***Intrinsic***
- ▶ ***Conclusion***

Proliferation Resistance: Definition and key concepts

Proliferation Resistance : in the news and in practice since a long time

- ▶ ***Inspection regimes and bilateral agreements :***
 - ◆ ***IAEA, Euratom, ABACC, etc..., bilateral US-Euratom, US-Japan***
- ▶ ***A concern addressed : LASCAR, safeguards in depth***
- ▶ ***Technical and political actions : RERTR, HEU take-back policy***
- ▶ ***INFCE, TOPS,***
- ▶ ***Addressed when designing new systems: GenIV, INPRO,..***



Definition of Proliferation Resistance

... is that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material or misuse of technology, by States in order to acquire nuclear weapons or other nuclear explosive devices

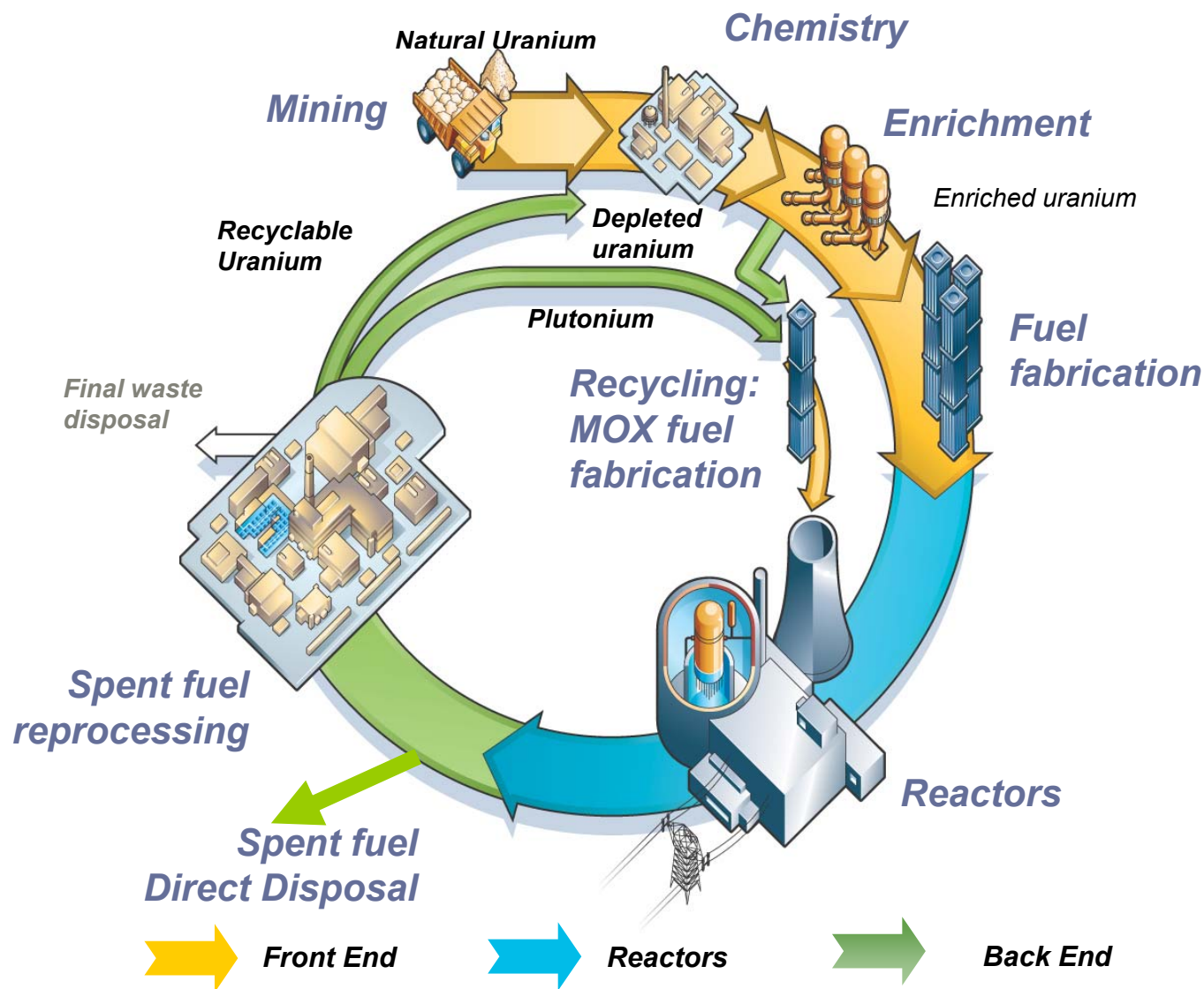
▶ ***Internationally agreed definition***

- ◆ ***Ref : IAEA's organized T.M. Oct. 2002 / STR-332, Dec 2002***
- ◆ ***Used widely : GIF / Gen IV,***

▶ ***Physical Protection is complementary, but different***

- ◆ ***There are some overlaps (e.g. : know where N.M. is)***

Nuclear Energy System: whole cycle and whole life cycle



Proliferation Resistance Key Concepts

- ▶ ***... degree of Proliferation Resistance results from a combination of, inter alia, technical design features, operational modalities, institutional arrangements and safeguards measures***
- ▶ ***Intrinsic features: technical design***
- ▶ ***Extrinsic measures: State's decision***

Intrinsic Features, Extrinsic Measures and the Concept of Barriers Defined in TOPS

▶ ***Material barriers***

- ◆ ***Pertaining to the nuclear material itself***

▶ ***Technical barriers***

- ◆ ***Pertaining to the technology and the facility***

▶ ***Institutional barriers***

- ◆ ***Safeguards and other extrinsic measures***

Intrinsic features and associated barriers Nuclear Material

▶ Attractiveness of nuclear material

(to design and manufacture a weapon)

♦ *Isotopic, chemical, radiological, mass and bulk*

▶ Isotopic as an example : further analysis

♦ *Critical mass, enrichment, spontaneous neutron fission, ...*

♦ *HEU 95% > LEU 19.95 % > LEU 5%*

♦ *Pu « Weapon grade » > Pu LWR @44 Gwd/t > Pu MOX S.F.*

▶ Safeguards: threshold are practical

▶ Proliferation Resistance: comparative analysis is meaningful, and helpful for designers

Intrinsic features and associated barriers

Facilities, Verification

▶ *Attractiveness of facility*

- ◆ ***Prevent / inhibit diversion, Prevent / inhibit undeclared production or misuse (Incl. Modification : cost, time, safety,..)***

▶ *Examples include*

- ◆ ***closed core more « robust » than on-line refueling***
- ◆ ***Fuel fabrication: fully automated plant more « robust »***
- ◆ ***Other intrinsic or extrinsic can effectively compensate***

▶ *Facilitating verification: intrinsic impact extrinsic*

- ◆ ***Facility unattractiveness and detectability***
- ◆ ***DIV, timely and accurate NMC&A system***

Extrinsic features and associated barriers

▶ *Commitments and Treaties*

- ◆ *NPT, Regional Treaties, ...***

▶ *Verification and controls*

- ◆ *IAEA : safeguards further enhanced by Additional Protocol***
- ◆ *Regional : Euratom, ABACC,***
- ◆ *Export control***

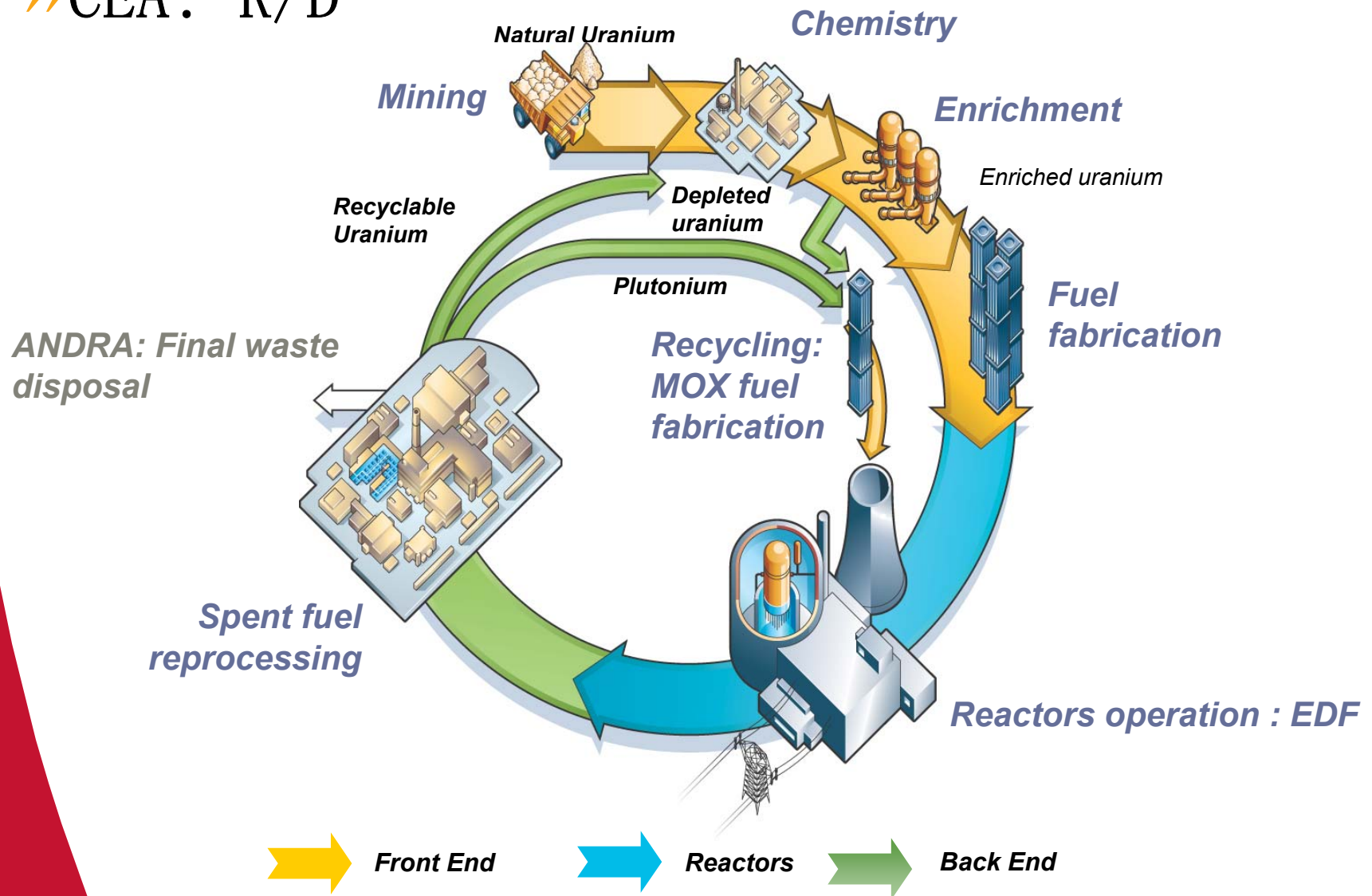
▶ *Industrial and commercial*

- ◆ *Location (need, number of « sensitive » facilities,)***
- ◆ *Open market, addressing security of supply concern, offering spent fuel management services***

Illustration of barriers through real life examples

The French Fuel Cycle

» CEA: R/D



Some extrinsic / institutional aspects

- ▶ ***France has signed NPT***
- ▶ ***France has a voluntary offer to the IAEA***
 - ◆ ***Safeguards and Additional Protocol***
- ▶ ***France is a member of European Union***
 - ◆ ***All nuclear material of the French nuclear energy system are under the safeguards of Euratom***
- ▶ ***France has an effective export control policy***
 - ◆ ***Member of NSG***
 - ◆ ***National and European legal and regulatory framework***
 - ◆ ***Bilateral agreements***

Extrinsic / nuclear energy system and location: industrial organisation serving worldwide needs

- ▶ ***Few key facilities (enrichment, reprocessing):***
 - ◆ ***Capitalistic investment, large capacity***
 - ◆ ***Serving a large number of reactors worldwide (> 100)***
- ▶ ***French illustration :***
 - ◆ ***Eurodif, serving French and international customers***
 - ◆ ***La Hague, a large reprocessing plant serving 100⁺ NPPs***
- ▶ ***Countries with small and medium size programs do not need to have their own facility on their territory***
- ▶ ***Reprocessing: removal of spent fuel reduces short term risk and long term concern of « plutonium mine »***

Extrinsic/ competitive and reliable supply

- ▶ ***Whatever the size of a program, needs of a country or of an operator of NPPs include:***
 - ◆ ***Security of supply / reliability***
 - ◆ ***Competitive price***
- ▶ ***Liberalised and open market ensure:***
 - ◆ ***Possible diversification of supply***
 - ◆ ***Competition to ensure optimal prices and innovative offers***
- ▶ ***It is one element of proliferation resistance***
- ▶ ***AREVA is a market player in a competitive environment in all steps of the fuel cycle***

Extrinsic/ multi-national control transparency

▶ *Multi-national control: a reality*

◆ *Enrichment: multi-national ownership*

- *Eurodif, URENCO***

◆ *UP-3 reprocessing plant:*

- *an initial « cost + fee contract » with capacity reservation***

◆ *Framatome-ANP: a franco-german merger (66% - 34%)*

▶ *Transparency* (in addition to control, safeguards, etc...)

◆ *EDF, AREVA, publish reports, audited accounts, ...*

◆ *AREVA has the legal status of a private company...*

◆ *.... the same duties and internal/external scrutiny*

Intrinsic feature: stabilisation of Pu inventory, making the best use of industrial recycling

- ▶ ***the MOX parity project : new MOX fuel management to achieve energy & economic balance between MOX and UOx fuels***
- ▶ ***MOX Aver. BU : 38 ↗ 45 GWd/t_{HM} (7% ↗ 8.65% Pu)***
- ▶ ***Target: stabilization of the separated Pu inventory and then of the spent fuel inventory in interim storage***
- ▶ ***Additional : through MOX fuel use, further degradation of the isotopic composition***

Proliferation Resistance and Assessment Methodology

- ▶ ***Proliferation resistance is a reality today, and it remains of importance for the future development of nuclear energy***
- ▶ ***Already developed proliferation resistance assessment methodology offers « building blocks » useful for the analyst and the designers (technical, safeguards, political)***
- ▶ ***Further work is needed to get towards an « as objective as possible » P.R.A.M. with internationally accepted concepts and tools***
- ▶ ***Proliferation Resistance is one of the element of choice, but do not forget others (safety, economics,)***

What it is all about ! Thank you

